DOCUMENTATION FOR THE AVIATION SYSTEM PERFORMANCE METRICS (ASPM)

ACTUAL VERSUS SCHEDULED METRICS

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1.0 INTRODUCTION

1.1 THE DEVELOPMENT OF ASPM

The Aviation System Performance Metrics (ASPM) was created by the Office of Aviation Policy and Plans to provide metrics by individual flight by phase of flight APO's main objective was to develop a clear and well-supported methodology to calculate metrics that would be accepted by both government and industry as valid, accurate, and reliable. Because the acceptance of the ASPM metrics is the key to its usefulness, APO coordinated the development of ASPM with other FAA organizations, major air carriers, and Air Transport Association.

ASPM combines data from several existing sources to estimate flight metrics at 50 major airports. ASPM uses data to provide detailed and accurate metrics than are available on a next day basis.

2.0 SOURCES OF ASPM DATA

2.1 INTRODUCTION

ASPM integrates data from two primary sources: the Enhanced Traffic Management System (ETMS) and Out, Off, On, and In (OOOI) data from ARINC. Additional scheduled data come from the Official Airline Guide (OAG). In addition, Airline Service Quality Performance (ASQP) data is integrated on a monthly basis.

It is important to note that each of these data sources was independently created for a specific purpose. Each source has its own strengths and limitations. ASPM was designed to take advantage of each data source's strengths and to overcome its limitations. Analysts must recognize the limitations of the basic data sources and remember that the ASPM-reported metrics are estimates and not actual measures. The reliability of the ASPM data varies from record to record. A record may have estimated values in some cases where some of the data sources are missing.

2.2 THE ENHANCED TRAFFIC MANAGEMENT SYSTEM

The Enhanced Traffic Management System, as its name implies, supports the daily management of the ATC system. ETMS data are collected automatically by the Air Route Traffic Control Center (ARTCC) computers for Instrument Flight Rules (IFR) flights. Although ETMS theoretically records all controlled traffic, in practice some flight information may not be recorded. ETMS data are automatically recorded, but this process is not monitored and there are periods of time when data are not recorded because of a computer or communications problem. In addition, when ARTCC computers are particularly busy they may temporarily cease to generate some ETMS messages.

ETMS contains complete flight information for all IFR flights, including air carrier, air taxi/commuter, general aviation and military operations. ETMS also has flight information for cargo flights and for the departures and arrivals of international flights. The ETMS messages include filed flight plans (FZ), departures (DZ), arrivals (AZ), position updates (TZ) and others. However, this flight information is recorded in ETMS as a string of flight messages, not as a complete flight record, so flight records must be constructed from numerous ETMS messages. Air Traffic (AT) uses customized software systems to organize the raw ETMS data and to match the messages into flight records.

The ETMS flight records profile actual flight performance, but because ETMS has no data on scheduled flight times, the extent to which actual flight times exceed expected flight times cannot be measured.

2.3 OOOI (OUT, OFF, ON, IN) DATA FROM ARINC

OOOI data are provided by ARINC for all flights for participating carriers. The carriers that are currently participating are:

American Airlines	Northwest Airlines	Alaska Air*
Air Canada	United Airlines	American Eagle*
Continental Airlines	UPS	America West*
Delta Air Lines	US Air	Southwest*
FEDEX		

*OOOI data obtained from ASQP data.

The primary ARINC data elements are the actual ground and flight movement times for each flight: gate departure (gate-out or OUT), takeoff (wheels-off or OFF), landing (wheels-on or ON) and gate arrival (gate-in or IN), collectively known as OOOI times. These data are automatically recorded by aircraft equipped with Aircraft Communication Reporting and Addressing (ACARS) sensors, processed by Aeronautical Radio, Incorporated (ARINC).

2.4 AIRLINE SERVICE QUALITY PERFORMANCE (ASQP)

The major airlines provide the Department of Transportation information on a monthly basis on the actual OOOI times for all domestic flights. This information is incorporated into ASPM by rerunning the data for that month. In addition ASQP provides cancelled flights and that data is also entered into ASPM in the rerun process.

2.5 OFFICIAL AIRLINE GUIDE

The Official Airline Guide lists planned flight times for all scheduled air carrier and commuter flights. The OAG contains flight information, including the type of aircraft used, for all domestic flights and for international flights originating or terminating in the U.S. The OAG does not contain information on non-scheduled and cargo flights or for general aviation or military operations.

OAG flight information is incorporated into the ASPM database with the OOOI data. The OAG planned times are used to compare actual to schedule departure.

2.6 ARRIVAL AND DEPARTURE RATES

The FAA Command Center collects data on a daily basis that contains information on runway configuration, arrival and departure rates and actual traffic counts by hour. This data is imported daily into ASPM.

2.7 CANCELLATIONS

Cancellations are obtained from ETMS File (record type is RZ). Once the ASQP file is obtained, cancellation data is updated.

2.8 WEATHER DATA

Currently weather data (ceiling, visibility, temperature, wind angle, and wind speed) is obtained from NOAA Internet site. Weather maps are obtained from weather.com 3 times each day.

2.9 UNIMPEDED TAXI TIMES

ASPM cannot compare taxi time to a scheduled taxi time because it has no data available on taxi times under optimal operating conditions. Therefore, APO developed a procedure to estimate this parameter. It is based on aircraft queue lengths by carrier and airport and uses a statistical function to estimate taxi times when the queues are of a minimal length. These estimates of taxi times are entered into the ASPM database and used to compare actual taxi time to unimpeded taxi time. The procedures used to develop the queues and to estimate the unimpeded taxi times are discussed in detail in Section 5 of this report.

3.0 ACTUAL VERSUS SCHEDULE METRICS

3.1 DEFINITION OF METRICS

ASPM provides data for both individual flights and for separate phases of each flight: gate, taxi-out, airborne and taxi-in. Each of these components can also be correlated to other flight characteristics, such as airport, carrier, season and so forth. The ASPM definitions are as follows:

Airborne--The difference between the actual flight time computed from ARINC OOOI data and the planned flight time in the flight plan filed with FAA and reported in ETMS.

Gate --The difference between the actual gate departure computed from ARINC data and the scheduled gate departure time reported in ETMS or the OAG.

Taxi-out--The difference between actual taxi-out time and unimpeded taxi-out time by airport, carrier and season. The unimpeded taxi-out time is the estimated taxi-out time for an aircraft under optimal operating conditions when neither congestion, weather, nor other factors delay it during its movement from gate to takeoff.

Taxi-in--The difference between actual taxi-in time and unimpeded taxi-in time by airport, carrier and season. The unimpeded taxi-in time is the estimated taxi-in time for an aircraft under optimal operating conditions, when neither congestion, weather, nor other factors delay it during its movement from landing to gate.

Block--The difference in the actual gate to gate time computed from ARINC OOOI data and the scheduled gate to gate time from the OAG.

Arrival--The difference in the actual arrival time that is extracted from ARINC OOOI data and the scheduled arrival time from OAG.

Airport—The difference in the actual wheels off and the scheduled gate out plus the unimpeded taxi out time.

3.2 OTHER FLIGHT CHARACTERISTICS

A major analytical advantage of ASPM is that the metrics for each individual flight can be correlated to other flight characteristics; these include the following:

Season--ASPM data are reported on a monthly basis and assembled into four seasonal blocks, representing winter, spring, summer, and fall.

Airport--ASPM provides information for flights at 50 U.S. airports.

Air Carrier--ASPM provides delay information for all air carrier flights.

Day of Month and time of Day--ASPM provides data by the day of the month and each flight is identified by time of scheduled departure and time of scheduled arrival.

Weather Conditions--The ASPM record structure contains fields for different measures of weather conditions, including ceiling, visibility, temperature, wind angle, and wind speed at both departure and arrival airports.

Runway Configuration--The particular combination of runways that is in use at an airport affects both capacity and patterns of operations. Runway configuration is particularly useful in calculating unimpeded taxi times, since changes in the distance and orientation between a particular carrier's gates and the runways in use for takeoffs and landings will vary.

4.0 ESTIMATION OF ACTUAL TIMES FOR NON ASPM PARTICIPATING CARRIERS

4.1 ESTIMATION OF ACTUAL TIMES

For carriers that are not participating in ASPM there is no information for actual times except for the DZ message and the AZ message time (these times are discussed in section 2.2). The following sections discuss the techniques for estimating actual times.

4.2 ESTIMATION OF WHEELS-OFF AND WHEELS-ON TIME

Using all ARINC flights, the median difference between the DZ message and wheels-off is computed by airport and day. This value is designated as the departure gap. The departure gap is then subtracted from the DZ time for all non-ARINC flights to obtain wheels-off. The departure gap is generally about 1 minute and is a fairly stable value.

In a similar manner, the median difference between wheels-on and the message time of the AZ message is computed by airport and day. This value is designated the arrival gap. The arrival gap is then added to the AZ message time for all non-ARINC flights to obtain wheels-on. There is more variability in the arrival gap then the departure gap. The arrival gap varies from a minus 5 to a plus 6.

4.3 ESTIMATION OF TAXI TIMES

Using all ARINC flights, the median taxi-out and median taxi-in time is computed by airport, day, and hour. The median taxi times by airport and day are also computed. The order for estimating taxi times for non-ARINC flights is as follows:

1. Use median by airport, day, and hour
2. Use median by airport and day

4.4 ESTIMATION OF GATE TIMES

For non-ARINC flights, the gate-out time is computed by subtracting the taxi-out time from the wheels-off time. In a like manner, the gate-in time is computed by adding the taxi-in time to the wheels-on time.

5.0 ESTIMATION OF UNIMPEDED TAXI TIME

5.1 DEFINITION OF UNIMPEDED TAXI TIME

Unimpeded taxi-out time is defined as the taxi-out time under optimal operating conditions, when neither congestion, weather nor other factors delay the aircraft during its movement from gate to takeoff. Unimpeded taxi-out time varies by airport, depending on the combination of gates and runways at that airport; by carrier at an airport, depending on the location of that carrier's gates relative to the runways being used for takeoffs; and by season, depending on the changes in normal operating procedures during each period.

5.2 ESTIMATION OF UNIMPEDED TAXI TIMES

Because ASPM has no data for expected taxi-out times under optimal operating conditions, unimpeded taxi-out times are estimated from data that are available. Unimpeded taxi-out time is defined as the taxi-out time under two simultaneous conditions--when the departure queue is equal to 1 and the arrival queue is equal to 0. The departure queue is the number of aircraft at each minute of the day that have pushed back from the gate (gate-out) but have not yet taken off (wheels-off). The departure queue is equal to 1 if a departing aircraft is the only one in motion when it pushes back from the gate. When another aircraft pushes back from its gate, the departure queue increases to Q=2 and so on until the first aircraft leaves the runway (wheels-off). The arrival queue is the number of aircraft that have landed (wheels-on) but have not yet reached the gate (gate-in). The arrival queue is equal to 0 if there are no aircraft landing (wheels-on) when the departing aircraft pushes back from the gate. The arrival queue increases in the same way as the departure queue until the first arriving aircraft reaches the gate.

The first step in the estimation of unimpeded taxi times is to determine the length of the departure and arrival queues for each minute. The departure and arrival queues are derived through a minute-by-minute analysis of actual flights in the ARINC database. There is one observation for each flight, for the length of the queues in the minute after it pushes back from the gate. Three values are identified for each flight: taxi-out time, number of aircraft in the departure queue and number of aircraft in the arrival queue.

ASPM uses a statistical function to estimate unimpeded taxi-out times by airport, carrier and season. The function is in the form of a multiple regression of two variables, with taxi-out time as the dependent variable and the queue lengths as independent variables. The regression equation is as follows:

$$TO_{a,c,s} = b_1 TOQ_{a,c,s} + b_2 TIQ_{a,c,s} + c$$

Where

TO	=	taxi-out time
TOQ	=	number of aircraft in taxi-out Queue
TIQ	=	number of aircraft in taxi-in Queue
a	=	airport
c	=	carrier
s	=	season
b_1	=	coefficient for TOQ
b_2	=	coefficient for TIQ
c	=	constant

Once the coefficients for the dependent variables are estimated from the regression, the unimpeded taxi-out time is estimated by setting the departure queue DQ=1 and the arrival queue AQ=0.

In estimating the unimpeded taxi-out times, the highest 25 percent of the values of actual taxi time were excluded from the regression. This step was taken to remove the influence of extremely large taxi-out times from the estimation of expected taxi time under optimal operating conditions.

The estimation of unimpeded taxi-out times has two important limitations. First, the impact of the use of different runway configurations on both actual taxi-out times and unimpeded taxi-out times could not be measured because no data are available on the runway configurations used for each flight

Second, the length of the departure and arrival queues is determined by an analysis of the flights for which OOOI data were available. These flights are a subset of the total activity at each airport. Because ASPM does not have data on all of the flight activity, it must be assumed that the queue lengths are minimum queue lengths and that the actual queues may be longer. Since the estimates of unimpeded taxi-out times are based on the value of the function when DQ=1 and AQ=0, but in reality DQ may be greater than 1 and AQ greater than 0, the estimated taxi-out times are not really unimpeded taxi-out times. However, when this is the case, the ASPM estimates would tend to be greater than the actual unimpeded taxi-out times.

6.0 GLOSSARY OF TERMS

% on Time Arrivals	Percentage of Arrivals that are less than 15 Minutes Late Arriving when Compared to Schedule
% on Time Departures	Percentage of Departures that are less than 15 Minutes late Departing when compared to Schedule
10th Percentile	A value below which 10 percent of data points occur
ASPM	Aviation System Performance Metrics
AAR	Airport Arrival Rate
Actual Block	Actual Gate to Gate Time
Actual Enroute	Actual Time from Wheels-Off to Wheels-On
Actual Gate In	Actual Time Arriving Gate
Actual Gate Out	Actual Time Departing Gate
Actual Wheels-Off	Wheels-Off Time from ARINC
ADR	Airport Departure Rate
Air Carrier	Air Carrier (Departure/Arrival/Operation)
Air Taxi	Air Taxi (Departure/Arrival/Operation)
Airborne	Actual Airborne Time minus Carrier Submitted Time Enroute
Aircraft	Aircraft Type
ARINC	Aeronautical Radio, Inc.
ARINC Present	Y if ARINC Record Present for Flight
ARR	Arrivals
Arr. Rate	Arrival Rate
Arr. Apt.	Arrival Airport
Arrival	Actual Gate in Minus Scheduled Gate in
Arrivals	Number of Arrivals for which Data are Available to Compute Taxi in Time
ASPM Arrivals	Number of Arrivals obtained by Merging ARINC and ETMS data
ASPM Departures	Number of Departures obtained by Merging ARINC and ETMS data
AZ	Time of Arrival Message in ETMS (Host computer Releases Flight)
Block	Actual Gate-to-Gate minus Scheduled Gate-to-Gate
Canceled Arrivals	OAG Scheduled Arrivals that were canceled
Canceled Departures	OAG Scheduled Departures that were canceled

Canceled Flights	OAG Scheduled Flights that were canceled
Carrier	3 Letter Carrier Code
Ceiling	Heights in 100 feet above the earth's surface of the lowest level of clouds that is reported as "broken," "overcast" or "obscured" that isn't considered partial or thin
COM	Commercial (Departure/Arrival/Operation)
Configuration	Runways in use at the time of an event (Departure/Arrival/Operation)
Date	Date of Event
DEP	Departures
Dep. Rate	Departure Rate
Dep. Apt.	Departure Airport
Departure Hour	Local Hour in which a departure occurred
Departures	Number of Departures for which data are Available to Compute Taxi Out Time
DZ	Departure Message (Time Host Computed Picks up Flight)
EDCT	Expected Departure Clearance Time
EDCT Wheels-Off	Expected Departure Clearance Time from ETMS
ETMS Present	Y if ETMS Record Present for Flight
Equipment	Aircraft Model
ETMS	Enhanced Traffic Management System
FAA Equipment Type	3 Character FAA Equipment Code
Flight Plan Gate Out	Scheduled Gate Out Time Specified in Flight Plan
Flight Plan Wheels-Off	Plan Wheels-Off Time From ETMS
Flights	Number of Flights between a City Pair
Flights with EDCT	Number of Flights having an Estimated Departure Clearance Time
FR	Freight (Departure/Arrival/Operation)
GA	General Aviation (Departure/Arrival/Operation)
Gap AZ	Wheels-on Minus AZ Message Time
Gap DZ	DZ Time Minus Wheels-Off (Generally About 1 Minute)
Gate	Actual Gate Departure Time minus Scheduled Gate Departure Time
General Aviation	General Aviation
IA	Instrument Approach Conditions
JET	Jet Engine Aircraft

Local Time	Local Time for Airport
Median	A value at which half of Data Points is above and the other half is below
MIL	Military (Departure/Arrival/Operation)
Military	Military (Departure/Arrival/Operation)
OAG	Official Airlines Guide
OAG Present	Y if OAG Record Present for Flight
On Time Arrivals	Arrivals less than 15 minutes late when compared to schedule
On Time Departures	Departures less than 15 minutes late when compared to schedule
OPS	Operations
OTH	Other (Departure/Arrival/Operation)
PIST	Piston Engine Aircraft
Planned Enroute	Enroute Time Specified in Flight Plan
Qtr	Quarter Hour (15 minute period)
Runway Configuration	Runways in use at the time of an event (Departure/Arrival/Operation)
Scheduled Arrivals	Scheduled Number of Arrivals for that time period
Scheduled Block	Scheduled Gate to Gate Time
Scheduled Departures	Scheduled Number of Departures for that time period
Scheduled Gate In	Scheduled Gate In Time
Scheduled Gate Out	Scheduled Gate Out Time
Scheduled Operations	Scheduled Number of Departures Plus Arrivals for that time period
Season	1—Dec to Feb, 2—Mar to May, 3—Jun to Aug, 4—Sep to Nov
Taxi-in	Actual Taxi-In Time minus Unimpeded Taxi-In Time
Taxi-out	Actual Taxi-out Time minus Unimpeded Taxi-Out Time
Temp	Temperature in Fahrenheit
Total Operations	Departures Plus Arrivals
Total Taxi-In Time	Total Sum of Taxi-In Time for Arrivals in a Time Period
Total Taxi-Out Time	Total Sum of Taxi-Out Time for Departures in a Time Period
Traffic Counts	Departures and Arrivals
TURBO	Turbo Prop Aircraft
TX	Air Taxi (Departure/Arrival/Operation)

Unimpeded Taxi-In Time	The estimated taxi-in time for an aircraft under optimal operating conditions, when neither congestion, weather nor other factors delay it during its movement from landing to gate. Multiple regression is used to estimate unimpeded taxi-in time.
Unimpeded Taxi-Out Time	The estimated taxi-out time for an aircraft under optimal operating conditions, when neither congestion, weather, nor other factors delay it during its movement from gate to wheels-off. Multiple regression is used to estimate unimpeded taxi-out time.
User Group	C—Commercial, F—Freight, T—Air Taxi
VA	Visual Approach Conditions
VFR/IFR Flag	VA—VFR Approach Conditions, IA—IFR Approach Conditions
Visibility	Visibility in Statute Miles for Flight Operations
Weather Conditions	Either Visual Approach Conditions (VA) or Instrument Approach Conditions (IA)
Wind Angle	Wind Direction
Wind Speed	Wind Velocity in Knots